THE UNITED STATES DREDGING AND CONSTRUCTION COMPANY

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UNITED STATES PATENT RIGHTS TO BE PURCHASED BY THE COMPANY.

No. 708,541 of 1902. Improved method of emptying dredging boats.

No. 776,049 of 1904. Improved dredging apparatus.

No. 776,050 of 1904. Improved dredging apparatus.

No. 776,051 of 1904. Improved dredging apparatus.

By the purchase of the patented inventions described, the UNITED STATES DREDGING AND CONSTRUCTION COMPANY *would also acquire the sole and entire right to purchase all or any alterations or improvements that are being or may be made by the inventor at any time thereon, and in addition the sole and entire right to take out in the United States Patent Rights for such improvements and alterations in all or any of the patents hereinbefore described, all Patent Rights so taken out becoming the absolute property of the Company, in addition to the Patent Rights more particularly mentioned hereinbefore.*

LACK OF IMPROVEMENT IN DREDGING APPARATUS.

Mechanical genius has not applied itself to the improvement of dredging apparatus, but has turned to more popular branches of engineering. Consequently dredging has been carried on with machines of the same type as were in use fifty years ago, on a scale which was then unthought of. These machines raise all the various materials in which dredging operations are conducted, and fifty years ago were capable of dredging ports and harbors quickly enough to cope with the amount of work necessary.

INCREASED SIZE OF VESSELS AND URGENT NEED OF DREDGING.

Within a few years, however, both cargo and passenger vessels have increased in size and draft to such an extent that few ports and harbors can accommodate the largest of them. Inability to accommodate these vessels means commercial extinction, and consequently ports all over the world are faced with dredging problems of great magnitude. Where a few years ago the removal of a few thousand cubic yards was all that was necessary, millions of cubic yards must now be dealt with. No port had time to accomplish a gradual increase of its accommodation facilities, and the immediate need of machines capable of removing materials with a speed which no adaptation of existing types could accomplish became apparent.

EVOLUTION OF THE FRUHLING SYSTEM.

The Suez Canal and Bazine's Suction Dredger—Sand.

When the Suez Canal was commenced it was soon found that machines then known could not deal efficiently with the vast quantities of sand of which the major portion of the work consisted. The difficulty was overcome by Monsieur Bazine with the Suction Dredger. This invention proved entirely successful in dealing with the material in which it was designed to work. At that time the chief dredging problem was the removal of sand-bars, and it was thought that with the suction dredger to deal with sand and the bucket dredger and grab or clam-shell dredger to deal with mud and clay and other heavier substances, dredging machinery was ready to deal with every description of work. Bazine, however, attempted to dredge mud with his machine and failed completely. Mud being then not a very great factor in dredging, slight importance was attached to the suction dredger's failure when such work was attempted.

When, however, the extent of dredging operations necessary was so suddenly increased, new problems faced the engineers. The suction dredger was again put to work in mud, and again failed. The reason for the failure is: Sand is a very heavy substance, which, when sucked up by the suction pipe of the dredger and emptied into barges or the dredger's own hold, falls very quickly to the bottom of the barge or hold, and, moreover, does not require the admixture of a very large percentage of water to be sucked up with it. Mud, on the other hand, requires to be mixed with a large percentage of water before the suction will draw it up the pipe, and, when emptied into the barge or hold, remains in suspension and does not sink to the bottom. The percentage of solids to water varies to a very great degree, but, it will be seen that, if 90 per cent. of water has to be drawn up with 10 per cent. of mud, only 10 per cent. of the power of the vessel is being effective in actual dredging, and the waste of power is obviously enormous.

THE KIEL CANAL AND THE FRUHLING SYSTEM OF DREDGING BY SUCTION.—MUD.

The urgent need of a machine to dredge the sand in the Suez Canal introduced Bazine and his suction dredger. The problem of dredging the mud and maintaining the entrances to the Kiel Canal gave rise to the invention of the FRUHLING SYSTEM OF DREDGING by Herr Otto Fruhling, of Brunswick in Germany. This invention enabled the suction system to be applied to the dredging of materials, which could only be accomplished previously by means of the bucket and clam or grab dredgers.

THE FRUHLING SYSTEM resulted in the dredging of the heavier materials with enormous increase in speed and decrease in cost, and moreover gave to the engineers a tool which could also be worked with even greater speed and economy in sand. In one dredger therefore is combined an implement which is a very considerable improvement in sand dredgers and an incalculable improvement in mud dredgers.

THE GERMAN GOVERNMENT AND THE FRUHLING SYSTEM.

The Fruhling system of dredging would not be acquired when in its experimental stage by the Company. Since 1902 the German Government has expended from $500,000 to $750,000 on the construction of these machines, has adopted the system throughout the empire, and has now under construction further machines to cost nearly twice the amount already expended during the last three years. Fruhling dredges are now being built for employment in nearly all the German ports of importance on the Baltic Sea.

In addition, the British Dredging Company, Ltd., has already constructed two of these vessels and has further vessels under construction, and lately despatched a dredger under her own steam from Holland to Shanghai. The vessel arrived at her destination without having experienced the slightest mishap. This quality of seaworthiness is one of the notable advantages of the type. No insurance premium above the ordinary marine rate for cargo vessels was paid on the vessel for the voyage, thus demonstrating the high idea of her qualities held by insurance firms. Seaworthiness is of no small importance when the necessity for long and rough voyages and work in rough waters is considered.

The Inventor, Herr Otto Fruhling, one of the greatest experts in dredging of the present time, has been retained as consulting engineer by the Company.

ADVANTAGES OF THE FRUHLING SYSTEM OF SUCTION DREDGING OVER OTHER SYSTEMS OF SUCTION DREDGING.

The numerous separate advantages ensuing from the use of the FRUHLING SYSTEM OF DREDGING are explained in detail and in technical language by experts in the accompanying reports. Its main advantages may, however, be tabulated as follows:

It is the only means whereby the SUCTION system of dredging may be equally successfully applied to work in MUD AND SAND.

It reduces the cost of working by 75 per cent.

It is the only system which ensures the dredging of a level bottom.

It is capable of working in a sea-way when it is impossible for other dredgers to be employed.

It can be employed in work in narrow and confined spaces such as canals, docks and wharfs without fear of undermining the foundations of such structures by the dredging of holes in proximity thereto.

It has been proved by years of exhaustive and complete trials undertaken with characteristic thoroughness by the German Government to possess all of the advantages mentioned above. Information regarding the system may be obtained by application to the German Government Harbor authorities in Germany.

VARIOUS MATERIALS MET WITH IN DREDGING.

The various grades of materials met with in dredging operations may be briefly enumerated as follows:

Sand, silt or sand and mud mixed, clayey mud, gravel (sand and stones mixed together); clay; "hard-pan," a material consisting of a peculiar kind of clay mixed with stones of larger size than those usually described as gravel, which hardens into a very hard cement-like substance; boulders, and bed or slab-rock.

Of these materials the FRUHLING SYSTEM can deal with all excepting clay, hard-pan, boulders, bed or slab rock, it is possible to deal with gravel, but it is not often attempted on account of its being apt to "score" or wear out the inner casing of the suction pipes.

SOME INSTANCES OF DREDGING AND EXCAVATION WORK IN THE UNITED STATES.

THE PANAMA CANAL.

Though the need for dredging the actual canal has not yet arrived, important maintenance dredging work must be at once proceeded with at the ports of COLON and PANAMA so that ocean-going vessels bringing supplies for the canal work may enter and leave in safety. The material met with in dredging work in these localities is MUD, and therefore peculiarly suitable to the Fruhling system.

As water is admitted to the completed portions of the Canal the amount of dredging work will of course increase, and as the Fruhling system is especially adapted to work in narrow spaces, dredges a perfectly level bottom, and deals with such a wide range of materials, it should be very largely employed in the dredging of the Canal. The great reduction of the expense of dredging work attained by use of the Fruhling system must also be an argument greatly in its favor.

The authorities who will superintend the construction, excavation and up-keep of the Canal must employ the best tools to accomplish the end in view, and it has been proved beyond any possibility of doubt by the German Government engineers, who are famous perhaps above all others for thoroughness and conservatism, that the Fruhling system is the best dredging tool extant for work in sand and mud.

Of the $200,000,000, or whatever the eventual sum may be, which is expended on the Panama Canal works, a very large portion must be expended in dredging work in material in which the Fruhling system has won its chief successes.

THE ERIE CANAL.

The Erie Canal also presents a great opportunity for the Company.

Between $5,000,000 and $6,000,000 have already been expended on the work, $10,000,000 having been set aside by the State as a first appropriation. During the next two or three months the balance of $4,000,000 of this sum will have to be paid out for work done, and a further sum set aside for new contracts.

The engineers' estimate of the total cost of the enterprise is $100,000,000, and there is little doubt but that the whole of this amount will be expended.

The work offers good opportunities for the employment of THE FRUHLING SYSTEM.

THE MISSISSIPPI RIVER COMMISSION.

This Commission was appointed many years ago by the United States Government, and has since been in almost continual session for the study of the problem presented by the Mississippi River in the obstructions continually arising throughout its navigable course.

Enormous amounts of money are annually spent in the attempts to keep the necessary channels open. The rapidity with which the sand and other materials accumulate renders the work of the Commission extremely onerous. The fact that it is sand and silt which causes so much trouble in this instance immediately suggests the use of the FRUHLING SYSTEM as a means whereby these accumulations can be dealt with. The matter will be investigated.

THE AMBROSE CHANNEL CONTRACT IN NEW YORK HARBOUR.

The contract for the dredging of the East or Ambrose channel in New York Harbour called for the removal of no less than 45,000,000 cubic yards of material, or some 60,000,000 tons—a work of international importance. The present channel is dangerously narrow and shallow, and provides absolutely inadequate accommodation for the traffic using it.

ARTICLE FROM "THE SCIENTIFIC AMERICAN" ON THE FRUHLING SYSTEM. COMMENTS ON THE APPLICABILITY OF THE FRUHLING SYSTEM TO THE WORK IN NEW YORK HARBOUR.

Showing the enormous extent of this contract, it may be mentioned that the total amount of material to be removed for the completion of the channel exceeds BY SIX TIMES THE TOTAL AMOUNT ANNUALLY DREDGED FROM THE GREAT ENGLISH PORTS OF MANCHESTER, HULL, LIVERPOOL, THE CLYDE, and LONDON.

One of the Fruhling dredges built for the German Government within the last year is the largest dredger in the world.

The following extract from the *Scientific American* is here quoted and comment made, showing what would have been the result of applying such a vessel to the New York contract.

EXTRACT FROM THE "SCIENTIFIC AMERICAN" FOR SEPTEMBER 2ND, 1905.

A GIANT DREDGE (THE FRUHLING DREDGER).

"*The gigantic dredger represented in the accompanying photograph has recently been completed by F. Schichau, of Elbing and Danzig, Germany, for the Imperial Navy, and it is intended for maintaining the channel of the* JADE RIVER *at a convenient depth.*

The dredges available in the Prussian seaports, up to this time, had proved unable to deal with the JADE CHANNEL, *which is rather shallow for the new, large draft German liners.*

This dredge, which is the BIGGEST IN THE WORLD, *sailed for Wilhelmshaven after a short test of its engines made in the Danzig shipyards, and in the latter part of December rapidly accomplished its trial dredging with splendid results.*

Whereas, the contracts called for an hourly output of 4,680 cubic yards in soft ground, the dredge BY FAR EXCEEDED THIS FIGURE, READILY DEALING WITH 6,500 CUBIC YARDS (*or about 7,700* TONS) PER HOUR, *instead of 4,680, as stipulated.*"

(NOTE.—The dredgers *Mills* and *Thomas*, the contractors' dredgers on the Ambrose Channel contract in New York Harbor, which are only slightly smaller than the dredge now described, TOGETHER dredged an average amount PER DAY OF ONLY 11,000 cubic yards during the year 1904 in easy sand, OR ONLY ABOUT ONE-HALF AS MUCH AGAIN AS THE FRUHLING DREDGER RAISED IN ONE HOUR BY ITSELF.)

"*In heavy sandy ground, of specific weight 1.96, the dredge excavated 4,680 cubic yards per hour, 65* PER CENT. OF SOLID GROUND BEING RAISED BY THE PRESSURE PIPES."

(NOTE.—The percentage of solids raised with the ordinary suction system RARELY EXCEEDS 10 per cent.)

"*As regards the speed stipulated by contract, this had to be 8 knots with full loads and tanks pumped full. The mean speed during a run of several hours' duration was, however, 10 knots instead of 8 knots, showing an enormous increase in the performance of the dredge. The coal consumption was extremely favorable, being 0.85 pounds per horse power per hour.*

Owing to this increase in output and speed the DREDGE IS ABLE TO RAISE AND REMOVE AS MUCH AS 31,200 CUBIC YARDS OF SOIL IN ONE DAY, *corresponding to a* YEARLY OUTPUT OF 7,800,000 CUBIC YARDS IN 250 WORKING DAYS."

[NOTE.—The latest Government figures, issued in October, 1905, show that the *Mills* and *Thomas* (referred to above) TOGETHER WITH THE TWO GOVERNMENT DREDGERS, the *Manhattan* and the *Atlantic*, which are of nearly the same size as the two contractors' dredgers, dredge and remove some 650,000 cubic yards per month, working night and day. THESE FIGURES SHOW THAT THESE FOUR DREDGERS WOULD IN A FULL YEAR OF 365 DAYS OF 24 HOURS EACH, ONLY JUST EQUAL THE WORK OF THE ONE FRUHLING DREDGE IN 250 DAYS, *i. e.*, 7,800,000.]

(And, in addition, it must be remembered that these four dredgers COST $1,700,000 TO BUILD, WHEREAS THE FRUHLING DREDGER DESCRIBED COST ONLY SOME $350,000.)

"*Each cubic yard of soil raised costs accordingly* LESS THAN 0.6 OF A CENT, INCLUDING ALLOWANCE FOR THE DEPRECIATION OF THE DREDGE."

(NOTE.—The average cost of dredging and removing soil on the New York Harbor contract to the Government and the contractors is about 5.50 cents per cubic yard.)

"*This result is quite unique and much more satisfactory than any of the figures so far realized, as the harbor dredges so far known raised each cubic yard of soil at an average cost of 9.6 cents. The Schichau shipyards, we are informed, have secured contracts for a number of these novel dredges, especially for foreign ports.*"

(NOTE.—Simple calculations show that had the Government constructed one Fruhling dredger, such as is described, and placed it on the New York contract, it would have saved:

In initial cost of construction $1,350,000
In working expenses on the total amount of material to be removed no less than..... $2,500,000

And would have been able to complete the work in less time.

PRICES PAID IN CONTRACT FOR DREDGING WORK.

Prices paid for dredging work vary considerably. For work in light materials such as sand or silt from 10 cents to 30 cents per cubic yard may be obtained and in cases of pressing urgency as much as 50 cents or even $1 per cubic yard has been paid. The amount to be dredged and the conditions under which dredging has to be carried out influence the price. For instance in the great work for dredging the channel in New York Harbour only 9 cents per cubic yard was paid. For work in the heavier materials it is even harder to give any set table of prices. It is only safe to say that from 30 cents up to almost any amount is paid. As much as $3 per cubic yard was paid in New York for the dredging of some 4,000 cubic yards of mud. The profits made out of this work must have been enormous, as even at 50 cents a profit of nearly 30 cents per cubic yard would have been realized—if not more than that. But in such small contracts the price has necessarily to be high to induce contractors to undertake the work.

The following table, compiled from the Annual Report of the Chief of Engineers of the United States Army, which gives the cost and object of some of the most important dredging works in America, serves very strikingly to show the great sums of money expended on a branch of the country's domestic affairs to which so little of its citizens' attention is given; and, in addition, affords further proof of the unrivalled opportunities and the vast field awaiting this Company.

BOSTON (Mass.). For a channel 1,000′ wide by 27′ deep; project adopted in 1892.....	$1,488,751
For a channel 1,200′ wide by 30′ deep; adopted in 1899.....	455,000
For a channel 1,200′ wide by 35′ deep; adopted in 1902.....	7,994,248
NEW HAVEN (Conn.). For a channel 400′ wide by 20′ deep; 4 miles long (3,287,000 cu. yds.).....	345,000
BALTIMORE (Md.). For maintenance of a channel 30′ deep; adopted in 1896 (annual payment of).....	50,000

CHARLESTON (S. C.). For a channel 600′ wide by 26′ deep; adopted in 1899 (between)	$4,000,000 and 5,000,000
CHESAPEAKE BAY. For a channel 100′ wide by 10′ deep; adopted in 1899	274,310
GREAT LAKES. For a channel between CHICAGO, DULUTH and BUFFALO, 300′ wide by 20′ deep; adopted in 1892	3,340,000
Reclamation work, Southern Idaho. SNAKE RIVER VALLEY, and a canal 69 miles long with 80′ width at bottom, adopted 1903	5,000,000
CLEVELAND (Ohio). For a channel to be dredged to a depth of 25′; adopted in 1899	478,400
GALVESTON (Tex.). A ship channel 100′ wide by 25′ deep, and a channel in the harbor 500′ wide and 25′ deep; adopted in 1903	4,000,000
And an annual payment for maintenance work of	100,000
PORTLAND HARBOUR (Me.). Dredging to a depth of 30′; adopted in 1896	946,250
SAN DIEGO HARBOUR (Cal.). For a channel 500′ wide and 24′ deep; adopted in 1900	542,850
MISSISSIPPI RIVER COMMISSION. For a channel 1,000′ wide and 35′ deep; adopted in 1900	6,000,000
Construction of tugs for upkeep, &c.; an annual payment of	150,000
MISSISSIPPI. Maintenance work in South Pass Channel; adopted in 1889; an annual payment of	100,000
(This being only an infinitesimal portion of the amount annually expended.)	
TAMPA BAY (Fla.). For a channel 500′ wide by 27′ deep; adopted in 1899	750,000
Diverting of YAZOO RIVER AND VICKSBURG HARBOUR (Miss.). Improvement, excavation of 5,836,366 cu. yds. earth	1,200,000
NORFOLK (Va.). For a channel 450′ wide and 28′ deep; adopted 1899.	359,516
WIMPAH BAY (S. C.). For construction of jetties and dredging; adopted 1902	1,848,000
MOBILE HARBOR (Ala.). A channel 100′ wide by 23′ deep; adopted in 1902	1,640,000
And a channel 300′ wide and 30′ deep	91,250
PAWTUCKET RIVER (R. I.). For a channel 100′ wide and 12′ deep; originally adopted in 1883 and further revised 1904	382,500
PASSAIC RIVER (N. J.). For a channel 200′ wide by 10′ deep; adopted 1892	547,697
ALBEMARLE SOUND (N. C.). For a channel 80′ wide by 9′ deep; adopted in 1890	306,667
PENSACOLA (Fla.). For a channel 500′ wide by 30′ deep; adopted in 1902. (part dredge construction.)	220,000
PHILADELPHIA (Penn.). For a channel 600′ feet wide by 30′ deep; adopted in 1899	5,810,000
ST. JOHN'S RIVER (Fla.). Dredge construction and for dredging; adopted in 1902	1,450,000

Savannah Harbour (Ga.). For Harbour Improvement; adopted in 1896	$992,250
Keweewan Bay to Lake Superior (Mich.). For canal construction, width 70′, depth 16′; adopted in 1896	1,115,000
Detroit River (Mich.). For a channel 600′ wide and 20′ deep between Detroit and Lake Erie; adopted in 1892	1,554,000
Revised and additional scheme adopted in 1902 for a channel 600′ wide by 21′ deep	2,200,000
Irrigation lake and canals at Roosevelt (Arizona), adopted 1901	31,500,000

CONSTRUCTION OF DREDGERS AND WORK FOR THE COMPANY.

A number of contracts for dredging work have already been offered on which the Fruhling system could be profitably employed, and contractors have everywhere evinced great interest in the system and have recognized its merits. It has not been deemed advisable, however, to make any decision as to what work the Company would undertake when formed, for the reason that the most minute details of any such work must be gone into with an amount of care and thoroughness it would be impossible to afford under the present circumstances.

Investigations of the conditions under which dredging operations are carried out and the positions of various contractors in relation to their progress in contracts undertaken by them have been made, and it is certain that the Company will when formed be able to obtain all the work it can conveniently handle. In fact it may be said that the amount of work the Company will be able to secure will only be limited by the amount of the Company's resources for the building of Fruhling dredgers.

In view of the fact that it will in any case be necessary that the Company shall know the cost of dredger construction plans and specifications, a model of a large Fruhling dredger has been prepared by Mr. William A. Fairburn, the Superintending Engineer to the Southern Pacific Atlantic Steamship Lines. Mr. Fairburn has the highest reputation as a designer of all types of steamships, and the two largest freight-carrying vessels in the world—the *Minnesota* and the *Dakota* (among many other large vessels) were designed by him. Moreover, Mr. Fairburn has introduced methods into steamship construction by which the cost of construction is very materially reduced without any sacrifice of efficiency. Mr. Fairburn has also had considerable experience in dredging matters, is thoroughly conversant with the main features of the Fruhling system, and is, in addition, impressed with its merits.

Before the completion of the plans now in course of preparation by Mr. Fairburn, Herr Fruhling would be consulted and the plans submitted to him. Herr Fruhling would prepare the specifications and plans for the construction of his dredging head and apparatus in accordance with the requirements of the hull designed by Mr. Fairburn. A dredger built on the plans prepared by two such experts would undoubtedly be the best obtainable.

The cost of the vessel Mr. Fairburn proposes would be $275,000. The vessel would be a "self-containing" dredge with a hopper capacity of 2,000 tons of dredged material. The dredging capacity would be 5,000 cubic yards per hour in good material. In difficult

material Mr. Fairburn is of opinion some 8,000 cubic yards could be dealt with in a day of ten working hours, *i. e.*, 200,000 cubic yards per month of 25 days.

The cost of operating the difficult material alluded to per month would be $5,200 per month. The various items of expense being estimated as follows:

Pay roll of complement	$937 00
Coal	1,125 00
Food	255 00
Oil, water and stores	175 00
Repairs	300 00
Superintendent	200 00
Office expenses	400 00
Depreciation	1,525 00
Insurance and miscellaneous expenses	283 00
TOTAL COST OF OPERATING FOR ONE MONTH	5,200 00

The figures for depreciation are based on the life of the boat being fifteen years—which is much less than the true life of the vessel should actually be. The other items in the foregoing table are estimated by Mr. Fairburn out of his great experience in the designing construction and management of steamships.

The plans, &c., of the dredger described should be of great value to the Company. It is not, of course, to be taken that the building of this dredger should be proceeded with as soon as the Company is formed. It would, of course, be quite possible to build a dredger on the Fruhling system for a sum much below that needed for the construction of such a vessel as is described hereinbefore. As instancing this fact the dredger reported on by Messrs. Flannery, Baggallay & Johnson, of London, England (in their report attached to this proposal), *i. e.*, the *Nicolaus*, engaged in maintaining the entrance to the Kiel Canal, cost only some $100,000 to build, and is capable of raising nearly 3,000 cubic yards per hour, but has hopper capacity for only some 500 tons, and is therefore much smaller than the vessel Mr. Fairburn is designing. It would be possible to build a Fruhling dredger without any hopper capacity capable of doing excellent work at 1,000 to 1,500 cubic yards per hour, at a cost of $75,000. The Company's first dredger will be constructed to meet the requirements of work undertaken, and will be dominated by the amount of funds at the Company's disposal. Such a vessel as is described would, however, be capable of undertaking work of the class it is desired to obtain, that is to say, of work of importance and magnitude. In such work the vessel would earn large profits.

It is necessary, however, that it should be well understood that it is not claimed for the FRUHLING SYSTEM that it is capable of undertaking dredging work in all sorts of materials. As has been previously pointed out herein there are various kinds of materials such as heavy clay and rocks which it is impossible to deal with under any circumstances by means of the suction system. To deal with these materials dredgers of the clam-shell, bucket or dipper type must be employed. In considering the suitability of contracts therefore it will be necessary to make the most careful investigations with a view to ascertaining as nearly as is possible the exact proportions of the materials

with which the Fruhling system can or cannot deal. Naturally those contracts offering the largest proportions of work in mud and sand will be first considered. It may very possibly happen that a contract will show 85% of mud and sand and 15% of rocks and heavy clay. In such cases it is the custom of the Government to offer the contract usually in two portions, *i. e.*, the hard and the soft work, at two different prices. If it is considered advisable to make an offer for the whole of the work in both soft and hard materials the Company will either hire or build dredgers for the work on the hard materials. In cases where the whole work must be tendered for, very careful figuring is necessary, and the advice of the best expert obtainable of the greatest importance. In these cases Herr Fruhling will be of inestimable value to the Company with his great dredging knowledge and experience.

The intentions of the proposed Company with regard to construction of plant have only been touched upon herein in the most general terms, for the reason that the policy of the Company will be in the hands of its Stockholders who will from the outset have perfect freedom in deciding the work that will be taken up and the work that will be avoided.

The machines it is proposed to purchase may be divided into two classes—MAIN and AUXILIARY. The main devices are THE FRUHLING PATENT SUCTION PIPE DREDGING HEAD ATTACHMENT. The auxiliary machines consist of various adaptations of the main device for work under extraordinary conditions. As instances, it may be said that Herr Fruhling has invented means for reversing the dredging head and dredging in a diagonal instead of a longitudinal manner. Herr Fruhling has also invented a system of piping for the scouring out of the holds of dredging vessels. This system has been fitted to each of the dredgers built for the German Government, with very marked success.

PROSPECTS OF THE COMPANY.

THE COMPANY OWNING THE FRÜHLING SYSTEM WILL BE ABLE TO UNDERTAKE DREDGING WORK AT A LOWER FIGURE THAN WILL BE POSSIBLE TO ANY COMPETITOR AND AT THE SAME TIME TO EARN LARGER PROFITS.

COPIES OF REPORTS, &c.

Certified copies of the report by Messrs. Flannery, Baggallay and Johnson and of the certificate by Herr Scholer on the FRUHLING SYSTEM may be seen at No. 15 William Street, New York (City), the office of Mr. W. Donald Angier. The original of the address on the Fruhling system given by Herr Scholer at the meeting of the International Navigation Congress at Dusseldorf is in Germany.

REPORTS.

FRÜHLING SYSTEM.

The following certificate shows the work done by the system on the Kiel Canal in Germany, and the high opinion in which it is there held by authorities most competent to judge:

KIEL, 12th March, 1903.—This is to certify that the dredger *Nicolaus* in the Emperor William Canal from the 15th October, 1901, to the 1st March, 1903, has dredged in 700 working hours 1,350,000 tons of sand, mud and silt, and has transported and discharged this material for a distance of 1.5 miles in 1,450 hours. The average cost of the above work (including transport) was three-fifths of a penny per ton (about one cent in U. S. A. currency).

After carefully watching the work done by the *Nicolaus* during the above period I am able to say that, in my opinion, the Fruhling system is the MOST RELIABLE, ECONOMICAL AND EFFECTIVE system of maintenance dredging I have seen.

(**Signed**) **SCHOLER.**

Chief Engineer to the German Gov., Member of the Imperial Canal Commission at Kiel.

Report No. 1.

REPORT made by
FLANNERY, BAGGALLAY & JOHNSON,
Consulting Engineers.

Sir FORTESCUE FLANNERY, M.I.C.E., M.I.M.E.
ROBERT BAGGALLAY, M.I.M.E.
ALEXANDER B. JOHNSON, M.I.N.A.
HERBERT B. GREGSON, Wh.Sc., A.M.I.C.E., M.I.N.A.
ERNEST C. GIVEN, A.M.I.C.E., A.M.Mech.E.

FRUHLING SYSTEM.

STEAM DREDGER "NICOLAUS."

9 FENCHURCH STREET,
LONDON,
October 6th, 1902.

To W. DONALD ANGIER.
DEAR SIR:

At your request we proceeded to Hamburg, and from there to Brunsbuttel, at the Elbe entrance of the Kaiser William or Kiel Canal, to inspect and report on the steam dredger "Nicolaus," fitted with dredging system by Herr O. Fruhling, of Brunswick.

We visited vessel on the 30th September, 1902, and found that the steam dredger "Nicolaus" had been constructed specially for working in and at the entrance of the Kaiser Wilhelm Canal, her dimensions being about 47 metres (155 feet) long by 8½ metres (28 feet) wide, these dimensions being the largest suitable for manœuvring and turning vessel round in the Canal.

On deck the machinery consists of a powerful double winch forward, fitted for the purpose of working two anchors to pull vessel forward, should it be necessary to work with anchors and chains instead of propellers; the anchors can also be used to aid propellers in forcing vessel forward should very stiff bottom be encountered. There are also four winches—two forward and two aft—for working the hoppers when this system of emptying vessel is used. Also a powerful crane aft for raising and lowering the

dredging gear. This crane is also designed for the purpose of raising wreckage, etc., and strongly ties the two halves of the stern of the vessel together. In addition there are several valves, valve-rods, etc., led through the deck for manipulating the valves in the piping system.

Vessel is constructed as a hopper dredger, and has three compartments for holding the dredged material, one forward of 200 cubic meters (261.6 cubic yards) capacity, and two aft, one on each side of the gap, of 100 cubic metres (130.8 cubic yards) capacity each, or a total capacity of 400 cubic metres (523.2 cubic yards). The boilers and machinery are situated amidships, and this arrangement of holds permits of vessel always being kept on an even keel.

The vessel is fitted with two sets of engines of 120 h.p. each, to drive the twin screws for propelling vessel, and in addition in the machinery department are: A compound engine of 150 h.p., which makes about 250 revolutions per minute when driving the centrifugal pump for dredging; a Blake pump $12'' \times 18\frac{1}{2}'' \times 14'' \times 12''$ for delivering water under pressure to dredger head, to scour out holds if necessary, or to be used for salvage operations; a dynamo, and the usual auxiliary machinery. Steam is supplied by two boilers of the ordinary marine type, working at a pressure of 8 atmospheres. The suction pipe has a diameter of $15\frac{3}{4}''$. We found the whole of the machinery apparently in very good condition.

The piping system of vessel is, in our opinion, very complete, and should the dredged material become too solid to be pumped out of the holds, it can be loosened and softened by means of opening the valves, or, should this not prove effective, by putting water under pressure through other pipes by means of the Blake pump. This arrangement is also patented by Herr Fruhling.

The special dredging apparatus invented by Herr O. Fruhling consists principally of a strong box girder, which contains the suction pipe, and is attached to vessel and held in position at the forward end of gap by two trunnions working in bearings. At the after end of the box girder is the specially-designed dredger head, which is raised or lowered as required through the gap in vessel by means of the crane at after end of vessel. The dredger head, which in this case is about $3\frac{1}{2}$ metres ($11\frac{1}{2}$ feet) wide, consists of two principal parts. The forward or front part is in the form of a bucket or scoop, having several sharp prongs or points on the edge. This, on being drawn forward, scoops up the material to be dredged; and should the material dredged be solid the prongs or points assist to atomize or split it up. The after or back part consists of a chamber which is termed the mixing chamber, into which the material dredged by the bucket is forced. It is from this mixing chamber that the dredged material is pumped.

The mixing is done by means of admitting water at the upper end of the box girder, through which it flows on the outside of the suction pipe into the mixing chamber, and the amount of water is controlled by means of levers from the deck.

Should the ground to be dredged be stiff soil, and require more atomizing or splitting up than can be done by the bucket and mixing as above mentioned, it can be loosened by the means of water under pressure, which is forced by the Blake pump through three pipes laid side by side and secured on top of the box girder, and which lead through smaller pipes into the prongs or points at the edge of bucket, and into the mixing

chambers. But in the case of the *Nicolaus* the material dredged off Brunsbuttel has required very little mixing water.

Vessel can be discharged either by the hopper or by the dredging pump, and pipes are arranged so that the dredged material can be discharged into hopper barges or on to the banks of the Canal. This arrangement also enables vessel to be more useful as a salvage boat, as the holds can be very rapidly filled or emptied, as desired.

In our opinion the Fruhling system has several great advantages, among which are the following, viz.:

(1.) Vessel is propelled while dredging, and therefore under control the whole time. This is of great importance in narrow waters or at entrance to docks, etc., especially where there is much traffic; and in addition, as vessel has not to be anchored or moored, much time is saved by not having to moor and unmoor.

(2.) Vessel being propelled while dredging with this system, the ground is cut or scooped up level to any required depth, thus obviating the risk of forming holes in the neighborhood of banks, etc., or of undermining them.

(3.) Vessel being propelled while dredging can cut or scoop up the ground for a width of 11.48 feet in any required direction till holes are filled, and can after discharging same by means of landmarks, etc., return and continue the levelling process.

(4.) That by the construction of the dredging head the Fruhling system combines several good points of the suction and bucket dredgers, the principal and most important of which is the power of dealing by suction with soil heavier and more clay-like than has hitherto been attempted successfully with a suction dredger.

(5.) That the amount of water pumped up is under the control of those working the vessel, and that it is not necessary to pump up more water than is required (in the case of mud) to moisten the mud for effective pumping.

(6.) That the material dredged containing only a small percentage of water, no time is wasted in waiting for material to settle or extra pumping to allow water to overflow from the holds, but as soon as holds are full vessel can proceed to the dumping ground.

(7.) The small number of working parts, so that wear and tear and repairs are reduced to a minimum.

(8.) The adaptability of the system to meet various local requirements.

We are informed by the Government Engineer in charge of the Brunsbuttell district that previous to the *Nicolaus* commencing work, it took a large bucket dredger and three steam hopper lighters working night and day to keep the channel clear, whereas the *Nicolaus* now does the work more effectively and works only ten hours per day.

From official accounts we find that *Nicolaus* has done the following work, viz.:—

Date.	Time Dredging.	Time Transporting and Discharging.	Total Time.	Quantity Dredged and Transported.	Total Cost of Wages, Stores and Upkeep.	Cost per Cubic Metre.	Equivalent in U. S. A. Currency Cost per Cu. Metre.	Equivalent in U. S. A. Currency Cost per Cu. Yard.
	Hrs. Mins.	Hrs. Mins.	Hrs. Mins.	Cubic Metres.	Marks.	Pfen.	Cents.	Cents.
From Oct. 14th, 1901, to Aug. 1st, 1902.	445 59	950 57	1,396 56	556,950	39,533.80	7.1	.986	.750
				Cubic Yards.	Dollars.			
				728,490.6	$9,670.68			

In the above table the transporting from October 14th, 1901, to April 13th, 1902, was for a distance of about 3 kilometres, and from April 14th, 1902, to August 1st, 1902, was principally inside the Canal, and transporting was for a distance of 12 kilometres, and the dredged material was discharged on land by means of the dredging pump.

At about 11.45 a.m. on 30th September, 1902, vessel unmoored in our presence from the quay and commenced dredging in inner harbor, to illustrate the working. Vessel then entered lock and was locked out of Canal, proceeded about 3 kilometres, where the dredged material was discharged, the forward compartment of 200 cubic metres being dumped through hoppers in 30 seconds, and the two after compartments of 100 cubic metres each being pumped overboard in $4\frac{1}{2}$ minutes. Vessel then returned to outer harbour and filled all three compartments in 16 minutes with mud, containing about 15 per cent. of water; then proceeded about 3 kilometres, and dumped the whole cargo in 30 seconds. Vessel then returned to the harbor at 1.45 p.m. We requested to see the whole of the compartments filled and pumped overboard or discharged on land. It was explained that the orifices to valves in the forward compartment had been blocked up with wood plugs by order of the authorities, as they were not required to be worked at present. But the Government Engineer of the district very courteously and kindly had the plugs removed.

At 3.52 p.m. vessel was cast off from quay and at once commenced dredging in inner harbor; all three compartments were filled in $12\frac{1}{2}$ minutes with black mud and fine sand; vessel then steamed along Canal for a distance of 12 kilometres, having to ease down when passing four steamers, and arriving opposite jetty at 4.52, or in exactly one hour; vessel was then turned round in the width of the Canal, the twin screws enabling this manœuvre to be executed with facility. Vessel was moored at 5.15 p.m. The shore pipe was connected by 5.29, dredging pipe was started, and all was discharged by 5.40, or in 11 minutes. Vessel then returned to Brunsbuttell, where she arrived at 6.23 p.m. The whole operation of dredging, transporting for 12 kilometres, etc., discharging and returning, occupying 2 hours 40 minutes.

We were permitted to attend and witness the above operations by the kindness and courtesy of Herr Gilbert, Chief Engineer Inspector of the Brunsbuttel district.

The above work, including delays for docking out of Canal, transporting, etc., deducting 25 per cent. for portion left in bottom of holds, increase in bulk, etc., and taking average of wages, stores, upkeep, etc., from previous table, the following table gives:—

Date.	Total Time Dredging, Transporting, &c.		Total Quantity after deducting 25 per cent.	Total Cost of Wages and Upkeep.	Cost per Cubic Metre.	Equivalent in U. S. A. currency per Cubic Metre.	Equivalent in U. S. A. currency per Cubic Yard.
	Hrs.	Mins.	Cubic Metres.	Marks.	Pfennig.	Cents.	Cents.
			900	64.63			
Sept. 30th, 1902	4	40	Cubic Yards.	Dollars.	7.18	1.666	1.040
			1,177.2	15.79			

The above results, especially that of the long period extending from October 14th, 1901, to August 1st, 1902, where on the average a cubic metre of solid material is dredged for 7.1 pfennigs (.986 cent) the cubic metre, appear to us to be very good.

The Fruhling system is intended to advance and cheapen the process of dredging by making it possible to apply the suction system to soils that have hitherto not been available for such a system, with its consequent economy.

Until about thirty years ago dredging was accomplished by buckets upon the well-known method, but after the cutting of the Suez Canal through sand by means of the Bazine or suction system of dredging, it was recognized that, in the case of sandy soils, a centrifugal pump, acting upon a suction pipe whose nozzle was placed close to the submerged sand it was desired to dredge, would clear away such spoil more quickly and more economically than the bucket system of dredging, and this centrifugal pump suction system has been applied ever since with economy and advantage wherever the soil has been sufficiently sandy. For clay or heavy soils, however, the suction system has never yet been satisfactory, and bucket dredging has consequently continued for situations in which such soils are met. Herr Fruhling's invention has for its object the application of suction dredging to soils that are less sandy and more in the nature of mud or clay than has hitherto been possible for under any previously known suction system.

The system may be briefly described as a combination of mechanism in which mechanical attrition is applied to heavy soil, and the same is simultaneously moistened by water projected upon it, so as to reduce the soil by mixture with water to mud, or an emulsion of sufficient fluidity to be acted upon by the suction of a centrifugal pump, thus enabling heavy soils to be worked with the same facility as sand. The soil in the neighborhood above referred to appears to have been easily dealt with in this way, and

it would, we think, be desirable if a sample of the material in its atomized and undiluted state be obtained for comparison with any soil that it is proposed to deal with under this system. There appears to be no doubt that many soils, hitherto capable of being worked only by the bucket or grab system, can under the Fruhling system be economically treated by suction, and therefore we regard the demonstration as most successful, proving a great advance in economy and despatch in future dredging operations.

Two patents have been submitted to us, namely, 19239 of 1898 and 16797 of 1900, the first being for the method of mixing the spoil with sludge, and removing it upon the suction system as above described, and the second being for a skilful method of mixing the sludge with water while it is deposited in the interior of the hopper for the purpose of being carried away to the dumping-ground, and in such manner as to keep the spoil sufficiently mixed with liquid to be pumped out of the hopper and deposited through the pipes on shore. In this way a vessel similar to the *Nicolaus*, constructed under the two patents above referred to, is adaptable both for winning spoil from docks, harbors and such like places, when the soil is less sandy than has hitherto been possible for suction, and is also adaptable to carry such spoil to a distance, and deliver it through pipes to the required place for making up artificial land, as is frequently required in harbor construction.

We are, Dear Sir,

Yours faithfully,

(Signed) FLANNERY, BAGGALLAY & JOHNSON.

Report No. 2.

Report

ON THE

FRÜHLING SYSTEM OF DREDGING

MADE TO

THE INTERNATIONAL NAVIGATION CONGRESS, DUSSELDORF, 1902.

BY

SCHOLER,

Kais. Regierungsrath and Member of the Imperial Canal Commission at Kiel.

The dredging operations, which are necessary to maintain the Emperor William Canal, have, owing to the special conditions under which they are to be carried on, necessitated the adoption of a new, specific method of dredging by suction, and to make extensive trials in this respect; and as very satisfactory results have been obtained during these trials, the dredger *Nicolaus* has been constructed on the principle adopted, and thus the new method has been thereby inaugurated for the first time.

Inventor.

The peculiar constructions in connection with the new method are the invention of Regierungs-Baumeister O. Frühling in Brunswick, and their details as well as the conditions which have led to its adoption and the trials made therewith are described in the present paper, because the results obtained during the trials seem to point to the possibility that dredgers of similar construction may be adopted elsewhere, too, with advantage.

Use of dredger for maintenance and excavation work.

The chief duties which the new dredger constructed for the Emperor William Canal will have to perform, and which were specially kept in view in working out all its details, were to keep open the entrance of the canal into the River Elbe, for which purpose it will have to clear away large quantities of mud, which the river is continually depositing in that locality; and also to carry out small, odd jobs of dredging in the canal itself, and in addition thereto to widen the bed of the canal at passing places and lay-by berths.

Use of dredger for salvage work.

Besides these chief duties, the new dredger was also to serve as a break-down floating derrick in case of accidents, to remove wrecks and to clear away with expedition any accumulation of sand caused by such break-downs or wrecks in the canal.

Advantage over ordinary bucket dredger.

Ordinary bucket dredgers would not have been suitable for this purpose, especially for performing the main duty, because their anchor chains and attendant scows would have most inconveniently blocked the entrance; besides which, they would not have possessed sufficient mobility to make way quickly for the crowded traffic continually passing through the entrance. Moreover, they would have had to be made of such large dimensions, to be able to fully

cope with the work, that the cross-section of the canal would have been unable to accommodate them.

Advantage for ordinary suction dredger.

Suction dredgers of the ordinary construction would have been equally unsuitable for the chosen purpose, because the material to be lifted mainly consisted of soft mud or silt, which could not have been worked with such dredgers, because it could not have been separated with sufficient rapidity from the excessively large volumes of water which have to be dealt with in this particular instance.

On the other hand, there were several good points to recommend the new dredger invented by Regierungs-Baumeister Frühling, who had carried out with it experiments on several occasions, and also small odd jobs near Rendsburg in the vicinity of the canal, with remarkably good results.

Reduction of water lifted with dredged material, &c.

This invention is an improvement on the ordinary suction dredger, and its advantages mainly consist in the feature, that the volume of water lifted with the dredged material can be regulated at will, and limited to the minimum quantity, which renders dredgers of this description specially suitable for removing soft mud. Moreover, it is possible to work with these dredgers to a uniformly level bottom, and the formation of holes and deep pools usually left by ordinary suction dredgers is thereby avoided; for this reason ordinary suction dredgers cannot be used in canals where the finished excavation is not to exceed a certain fixed maximum cross-section.

Description of invention.

The special apparatus by which the advantages mentioned above are attained consists of a dredging end-piece or head of special construction which is fixed to the end of the suction tube, and is formed by two principal parts.

One of these, the foremost portion, is of the shape of dredging bucket which excavates the ground mechanically, leaving a level flat bottom.

The other, hindmost portion forms a chamber or receiver, closed all round, into which the excavated material is pushed in, and into which the necessary volume of water can also be admitted in adjustable proportions. The excavated material and requisite quantity of water for pumping it away are then mixed in the receiver, and the slurry thus formed is lifted by the pump.

The receptacle wherein the excavated material is mixed with water is suitably constructed for that purpose, and when working in compact ground the work of excavation and mixing is assisted by pressure water, which can be directed in powerful streams upon the exact spot where the ground is to be excavated. This system of dredging seemed to be eminently adapted to the existing requirements, and it was, therefore, proposed for adoption, on the understanding, however, that its efficiency was to be first proved by preliminary trials on a larger scale.

Trials with a remodelled lighter.

To carry out these experiments an existing steam lighter was reconstructed and fitted up as a dredger by Frühling on the system invented by him, secured by patents.

The lighter was of the usual construction, had stowage room of 150

cubic meters capacity, was fitted with a compound engine, with surface condensation, of 185 indicated H.P., a boiler with 65 square meters heating surface working at 8 atmospheres excess pressure, 2 hopper-winches, and a simple anchor winch worked by hand gear.

To turn her into a dredger, the additional fittings consisted of a suction pump with direct acting engine, suction and delivery pipes for dredging, pipes for water for mixing purposes, pump and piping for forcing pressure water, a dredging head, a dredging crane combined with two stern winches, and a double forward winch.

The dredging pump was a centrifugal pump with impeller 900 millimeters in diameter, and made 200 revolutions per minute. It was driven by a direct coupled engine of 75 I.H.P.

The dredging conduit consisted of a plate girder with two fixed arms. The two arms enclosed the hull between them, reaching up on either side, and turned round pivots fixed to the sides of the hull. The other end of the girder was suspended by wire ropes, working round pulleys, from the dredger crane which was fixed on the deck abaft. The dredging head, of special construction, was fixed underneath the lower end of the ladder, and two pipes led from it on to the deck. The suction pipe was fixed on the port side, and ran up on one arm to the pump. The other arm, on the starboard side, carried two more pipes, one for conveying the pressure water to the dredging head, the other the water necessary for mixing the slurry in the receiver. The pressure water, as already stated, was supplied by a special force pump. The other pipe, conveying water to the receiver for mixing with the dredgings, had an inlet close to the end of the arm, the size of the opening of which could be opened and closed and regulated by a valve from the deck, and more or less water admitted to the pipe at will. The water to be conveyed to the mixer and receiver was sucked in by the sucking action of the dredging pump.

The dredging head was 3.5 meters broad. When about to dredge, it was lowered by the crane into position, and was dragged along the bottom by the dredger.

The dredger was moved ahead by two powerful forward winches, and made a straight cut 3.5 meters broad; arrived at the end of the cut, it was hauled back by the two stern winches, and moving forward again made a second, deeper cut or changed its position and made a fresh cut sideways.

The excavated material was delivered by the pump into barges lying alongside, or was forced through a delivery pipe line, 100 meters long, and deposited at convenient places on the banks.

The dredger started work in the autumn of 1900, and was subjected to extensive trials. After it had undergone various improvements and its crew had been properly trained to the work, the dredger worked with perfect satisfaction both in mud and in sand, and is still continuously employed in maintenance work on the canal.

The work performed by the dredger, considering the small power of the

pump, is truly remarkable. It can load a scow of 150 cubic meters capacity in 15 minutes. Working in mud, the dredger delivers the excavated material in such a state of consistency that, if caught up in a tub at the mouth of the delivery pipe, it forms a heap that will stand for hours without running off. According to the density of the mud, when deposited, it contains from 60 to 90 per cent. of excavated solid material in its mass.

When excavating fine sand the work of the dredger also compares favorably with that performed by other suction dredgers, though the work done in this case did not give such good results as when excavating mud. When dealing with fine sand, the volume of slurry delivered by the dredger only contained about 20 per cent. of excavated material in its mass.

After lengthy trials and numerous alterations in the shape of the excavating head, the dredger now works as satisfactorily in sand as in mud. The quantity of sand delivered in the slurry can now be increased in proportion to the power of the pump, and from 40 to 50 per cent. of it can be attained without difficulty.

System adopted and *Nicolaus* built

In view of the satisfactory results attained during the trial working, Frühling's system of dredging has been definitely adopted for the newly projected dredger *Nicolaus*, which has been designed in accordance with the special requirements of the Emperor William Canal already mentioned, and the experience gained during the experiments has been duly utilized in working out its details.

The design, construction and delivery, fully equipped for the work, was entrusted to Regierungs-Baumeister Frühling, of Brunswick. The dredger was built in the course of 1900 and 1901, delivered in September 1901 and set to work,

Description of *Nicolaus*.

The equipment for dredging has been arranged in a manner similar to that adopted on the experimental dredger, with the exception that the arms of the ladder and the various pipes have been combined into one whole, and are carried up through a gap in the centre instead of at the sides of the hull. The object of this alteration was to provide better protection for the various conduits, to give the dredger more mobility, and to enable other barges, scows and boats to lie alongside more conveniently.

The dredging conduit is formed by a box girder, of quadrangular cross-section, which has an enlargement at its lower end, and rests on a horizontal shaft at its upper end. The dredging head is fixed to the enlargement at the lower end, and the box girder rests, by means of the shaft at its upper end, in the central gap on plummer blocks.

The construction of the dredging head is similar to that on the experimental dredger.

The suction pipe is led on the port side of the dredging head, through the enlargement, up through the inside of the box girder. It consists of a 400-millimeter tube which ends in the horizontal shaft on the box girder in a

cylinder which surrounds a similarly shaped junction pipe, leading to the suction pump.

The water intended for mixing with the excavated material is led down through the inside space left unoccupied by the suction pipe. For this purpose the upper end of the box girder is closed by a diaphragm, and inlet holes are provided in the sides of the girder for the admission of water. These inlet holes can be opened and closed at will by movable louvres worked from the deck.

The piping for conveying pressure water to the mixing chamber is carried on the top plate of the box girder and is connected with the force pump by movable pipes. The piping consists of three pipes laid side by side and leading down to the dredging head, where they branch off into a number of single pipes, some of which lead to the cutting edge of the head, others to the interior, where they can assist the cutting apparatus at will in loosening the ground with pressure water when working in stiff soil.

The force pump delivering pressure water is a direct acting Blake pump of 40 H.P.

The dredging pump has an impeller of 1,150 millimeters diameter, is driven direct by a compound engine of 150 H.P., and makes from 200 to 250 revolutions per minute. The pump delivers the excavated material through a force pipe laid along the deck into the hold of the dredger, or through lateral overflow pipes into scows moored alongside the dredger, or through an extension of the delivery pipe to a distance of 200 meters, and up to a height of 5 meters on the banks of the canal sideways.

The whole dredging conduit is suspended from a powerful crane fixed abaft on the deck. This crane can lift 20 tons at a speed of 3 meters per minute, and forms at the same time a stiff connection between the two stern halves of the hull of the dredger. The dredging conduit resting in the central gap is removable, and the whole conduit can be lifted out of the gap and hoisted above deck. When at work the dredger is generally propelled by screws, without any chains. For this purpose there are, besides the engines working the pumps, two special engines, of 120 H. P. each, provided for working the propellers. These can propel the dredger at a speed of 16 kilometers per hour unloaded, and at 12 kilometers when loaded. When excavating ground of medium stiffness, the dredger can travel forward at a sufficient speed to enable the dredging head to cut just sufficient material; that is, the dredging head will excavate as much material in front as the pump will be able to remove from the mixing chamber behind.

The dredging of the bottom is done in this case also in long strips, 3.5 meters wide. After leaving off work and returning from the dumping ground, or when starting work on a new site, the dredger can take up its position without difficulty with the help of convenient land marks. Being able to move the dredger forward, when at work, by means of propellers only, and without any chains, has its special advantages, when working near the entrance of the

canal, as it does not interfere with navigation, and removes all dangers arising from the use of chains in dredger working. This arrangement has, besides, the advantage of increasing the quantity of work done by the dredger, because a great deal of time is usually lost in dropping and picking up the chains, when working with other kinds of dredgers, which time can be saved completely now and more profitably employed in doing useful work.

The dredger is provided with compartments for loading the excavated material; it is constructed as a hopper dredger. It was advisable to adopt this construction in view of the special conditions obtaining at Brunsbüttel (at the canal entrance), which necessitated the adoption of some method of dredging that was to be as simple as possible, and could be effected by employing a single boat only. All three compartments together will hold 400 cubic meters; there being two of 100 cubic meters each, and one of 200 cubic meters capacity. The two smaller holds are one on either side of the central gap or slit, and the large one in front of the engine room and stokehold, which are placed amidships.

Such a distribution of the holds makes it possible to properly adjust the loading of the boat and to distribute the material uniformly, so that the dredger, whether loaded or empty, will always float on an even keel.

The dredger is emptied through hoppers in the bottom, which are opened and closed by four steam winches placed on deck.

There is besides a contrivance by which the material in the holds can be lifted by the suction pump and delivered on to the banks. The dredger is fitted also with an elevator apparatus.

These equipments also were found necessary to suit the working to the special conditions on the Emperor William Canal, as there are very few places along its route where the hoppers can discharge the excavated material, and special provisions had to be made, therefore, to be able to deposit the dredgings at convenient places anywhere on the banks direct from the dredger.

The elevator equipment provided for this purpose consists of three pipe conduits built into the hull and leading to the suction pump. The pipes run alongside the holds and have a number of openings closed by flaps, leading to the holds. The dredgings in the holds can be exhausted through these openings, which being distributed all over the bottoms of the holds render it possible to empty the three compartments gradually and uniformly all over their areas. In case of the dredgings in the holds having become solidified they can be remixed with water before the material is lifted by the suction pump, for which purpose there are four other tubes provided besides the three suction pipes already mentioned. The four pipes for the delivery of the water required for mixing have also openings into the holds, which are placed opposite the inlets to the suction pipes.

The sucking action of the pump produces a stream running across the hold from the delivery to the suction pipes, which loosens the deposited material in the hold and carries it away with it. The loosening can be

assisted by pressure water, which can be conveyed down special tubes into the waterpipes and intensifies the streams of water across the holds.

This arrangement which is also the invention of Regierungs-Baumeister Frühling, and has been patented, has also answered very well.

The hull of the dredger is 46.68 meters long by 8.48 meters beam, and 3.7 meters deep. These dimensions have been adopted to suit the cross-section of the canal, so that the dredger can easily turn round and manœuvre about on the canal. In view of these requirements, the dimensions given above could not very well be exceeded.

Over and above the machinery and equipment already mentioned, there are also on board a central condensing apparatus with forewarmer, an electric light installation for arc and glow lamps and projectors, a steam steering gear and the usual auxiliary machinery.

There is besides on deck a powerful double forward winch, which can move the dredger forward at a speed of 10 meters per minute and exert a pull of 16 tons. This is provided for the purpose of hauling the dredger forward, when it is intended to work with chains and without propellers. Steam is supplied by 2 tubular boilers working at a pressure of 8 atmospheres above atmospheric pressure, and having a heating surface of 110 square meters each. The consumption of coals is 0.35 ton per hour while dredging, and 0.24 ton when steaming with full load.

Use as break-down floating derrick and salvage boat.

In order to enable the dredger to fulfil its subsidiary duties as a break-down floating derrick and salvage boat, it is fitted in a convenient manner with all the necessary equipment for such purposes, as, *e. g.*, with ample pumping power, etc. The powerful crane can be used in case of break-downs and for raising wreckage; and, as already stated, there is also the possibility of self-filling and self-clearing the holds in the boat.

The crew consists of the captain, cockswain, 3 sailors, cook, 2 engineers and 3 stokers; 11 men in all.

Work performed.

The efficiency of the work done by the dredger as regards consistency of the excavated material and proportion of solid matter contained in the dredgings is the same as that of the experimental dredger. Owing to the use of a more powerful pump, the quantity of work done by the new dredger is, of course, greater. When working at the canal entrance near Brunsbüttel, the holds of 400 cubic meters capacity are upon an average filled in 16 minutes. The excavated material is then taken away to a distance of 3 kilometers and discharged through the hoppers. Working ten hours the dredger can in this manner make 13 such full trips on an average, including any delays by navigation. The quantity of work done in excavation can not, owing to local conditions, be arrived at in any other way than by measuring the volume of material deposited in the holds. Deducting from the cubic capacity of the holds 33 per cent. on account of incomplete filling and for increase in bulk, the quantity of earthwork removed by the dredger under above-mentioned working conditions may be reckoned in round figures at 1,000 cubic meters per

hour, and the day's work at ten working hours, consisting of excavation, carrying off the dredgings to a distance of 3 kilometers and discharging them through the hoppers at 3,500 cubic meters.

The working expenses of the dredger amount to 150 marks per day upon an average.

Calculations have also been made with regard to the specific gravity of the excavated material.

According to the conditions prevailing at Brunsbüttel it has been found that the dredger can perform the greatest amount of work if the specific gravity of the dredgings is kept down to 1.275. The principal bulk of the mud, which has to be dredged at Brunsbüttel to standard cross-section, as it lies at the bottom, that is, before it has time to consolidate completely, has an average specific gravity of about 1.3 or 1.33 respectively. At greater depths this increases to 1.4, and even as much as 1.6. According to these weights, the percentage of solid material contained in dredgings of a specific gravity of 1.275 would amount to 90 per cent., or 83 per cent., or 68 per cent. or 46 per cent. respectively.

Before the dredger *Nicolaus* started work, the necessary dredging to be done at the canal entrance was performed by a large bucket dredger and three steam hopper-barges. Working under similar conditions as those upon which the work done by the dredger *Nicolaus* has been computed above, the four boats excavated 1,500 cubic meters only per day, and entailed a daily working expenditure of about 380 marks in round figures.